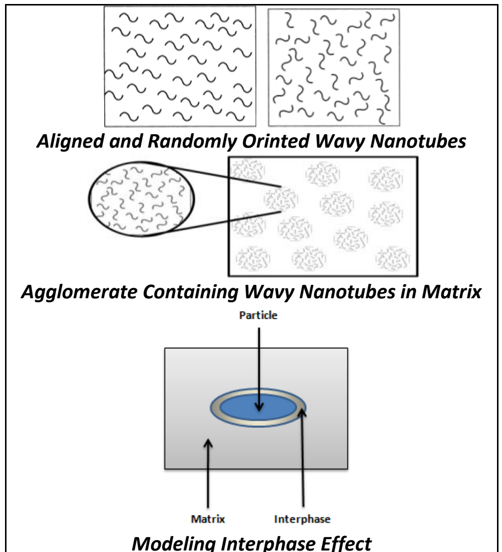
Prediction of Effect of Waviness, Interfacial Bonding and Agglomeration of Carbon Nanotubes on their Polymer Composites

Challenge

Carbon nanotubes (CNTs) show superior mechanical and physical properties and seem to be promising ideal reinforcing material for polymer matrix composites of high strength and low density. In most of the experimental results till date, however, only modest or negligible improvements in stiffness and strength have been observed. The reason for less than expected improvements have been blamed on weak interfacial bonding of CNTs to the matrix, waviness in CNTs, and agglomeration of CNTs in resin at higher particle volume fractions. The key objective of this case study is to show the effect of interfacial bonding, waviness, and agglomerations on the nano-composite stiffness, Poisson's ratio and strength.

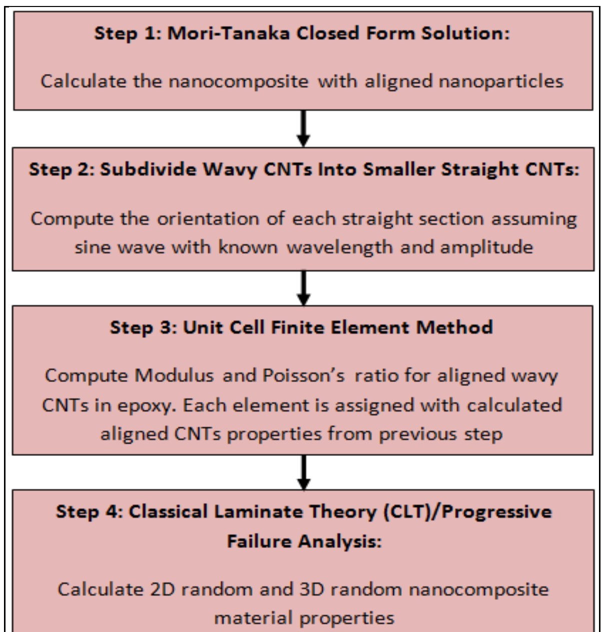


Factors Adversely Affecting Nano Composite Properties

Solution

Methodology involved in the case study includes Mori-Tanaka, Subdivide Wavy CNTs into smaller CNTs and implement Unit Cell Finite Element Method, Classical Laminate Theory (Analytical). The step by step process involved in this case study are listed below and the work-flow to predict material properties for aligned, 2D and 3D randomly oriented straight and wavy MWCNTs in matrix is also shown.

- **Step-1:** Consider the fiber to be straight
- **Step-2:** Consider the fiber to be wavy
- **Step-3:** Include interphase between the fiber and the matrix as well as consider fiber to be wavy
- **Step-4:** Include the effect of agglomerations as well as consider fiber to be wavy (no interphase)



Flowchart to predict material properties for aligned, 2D and 3D randomly oriented straight and wavy MWCNTs in matrix

Results & Conclusion

- Comparison of modulus and strength between various predictions for straight and wavy MWCNTs reinforced composite.
- Effect of agglomeration and interphase in modulus and strength prediction.
- Interphase and agglomeration can significantly affect both the modulus and strength.

Key Highlights & Benefits
Product: MCQ-Chopped
Industry: Aerospace and Automotive
Application: Carbon Nanotubes Enhanced Matrix
Performance: (**1**) De-Homogenization Approach: models composite constituents and chopped fiber orientation; (**2**) Considers effect of Defects; (**3**) Accurately predicts strength in addition to stiffness

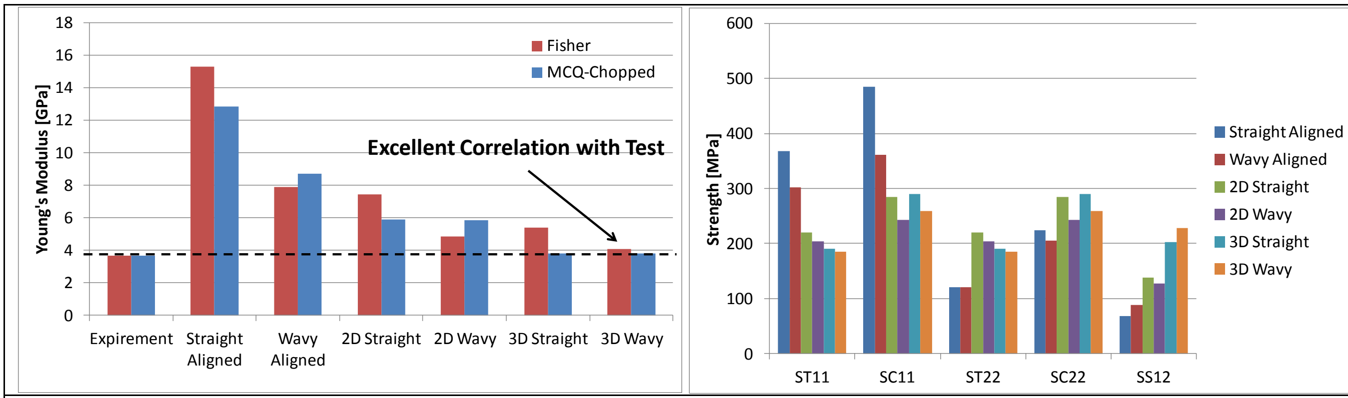


Figure 3. Comparison of Modulus and Strength for straight and wavy MWCNTs reinforced composite

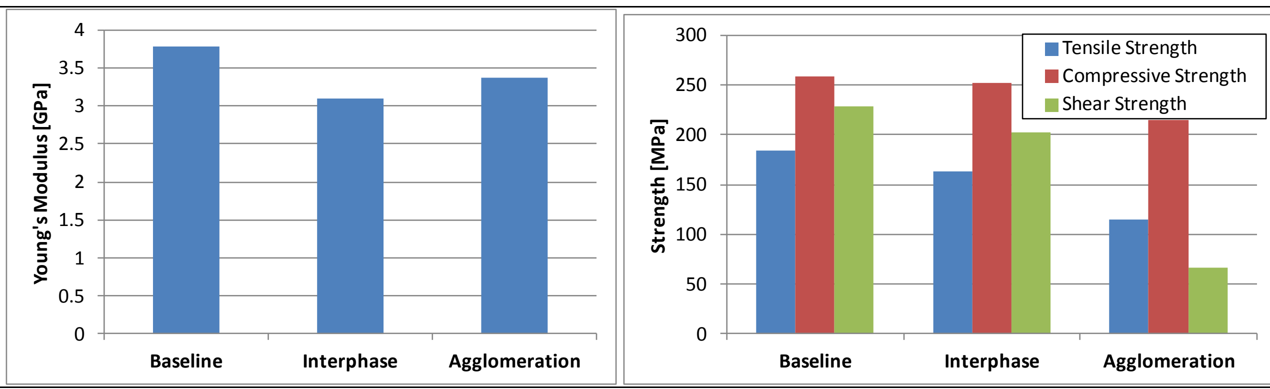


Figure 4. Effect of agglomeration and interphase on modulus and strength

Related Publication

Prediction of Effect of Waviness, Interfacial Bonding And Agglomeration Of Carbon Nanotubes On Their Polymer Composites, SAMPE-Conference, Long Beach, CA-May 2013.